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The present crisis in plant physiology[1]

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The last decade has been characterized by a rapid and remarkable development of a world-wide consciousness of the rôle of science in human life. Although this consciousness has been long present in some minds and sporadically evident in the writings of some authors, it has only recently diffused and become well-nigh universal among thoughtful people. Practical application of scientific knowledge in the ordinary affairs of life is now generally and widely appreciated and the scientific method of thought is everywhere in demand for the production of physical necessities, conveniences and luxuries. Everyone knows that science is in the midst of remaking the physical and biological world. There is strong demand that it be especially prompt about all the details that so obviously have needed intelligent attention for so long.

Also the ethical and aesthetic values of scientific accomplishment and scientific culture are being increasingly appreciated in this period of regeneration, whether with brave joy or with fearful misgiving. Many careful thinkers are able to see in the rapidly increasing body of scientific knowledge the promise of an approaching release from many of the spiritual as well as material troubles of mankind; *veritas scientiae vos liberabit*, for science is remaking the spiritual world as well as the more tangible and directly familiar one. The conscious purpose of far-reaching human intelligence which really approaches omniscience from the standpoint of primitive culture, although now

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only in its own embryonic phase, is bent on improving the world for human needs and sensitivities, by sorting and arranging an apparent chaos of seemingly random happenings. In this particular period of heightened intellectual activity and spiritual yearning, the beginnings of a race consciousness seem more evident than ever before in similar periods. It may be that the universe conscious of itself—long dreamed of or mystically hypothetised— may be developing at length, at least in the form of the human world conscious of its past and present and bold to take charge of its own future at whatever risk. Weak as it still is, this embryonic race consciousness is already highly significant. It is armed with the recently developed methods of science and it aims to move steadily forward in the understanding and appreciation of humanity and human surroundings. Imagined by many cults as already existent somewhere in the voids of the universe, or perhaps permeating it like an imponderable ether, this driving purpose toward natural betterment, toward good things that are to be secured for humanity, here on our planet, seems now to be actually recognized, evolving and emerging in our very selves. Is the mythical Zeitgeist really turning the future of humanity over to this human spirit of conscious progress?

On the other hand, many people in their outlook on the unknown are guided by a familiar conservatism of feeling, refusing to risk the flights of thought excepting in practical affairs. These seem generally not yet to have grasped the deeper implications of physical and biological accomplishments. They protest strongly against scientific progress as a terrible disease of the ancient system of spiritual values, which must somehow be checked in its ravages—even by blood-letting and the heroic infliction of pain (on others), if such things should prove necessary. No one of any class, however, appears to oppose science as seriously undesirable from the standpoint of ordinary practical affairs, and its advance can now derive the very salutary stimulation of opposition only from reactionary views on moral, ethical and aesthetic values. Indeed, those who lead in decrying the philosophy of science apparently find no great difficulty in accepting with free acclaim the quotidian conveniences and wealth-producing opportunities with which scientific endeavor has already variously flooded the world, and a few of these

clamorous opponents of the freedom of thought are actually engaged in scientific research in some field where results may be applied and perhaps lucrative, without too seriously disturbing the moral and religious feelings of any one. Science aims toward consistency and its opponents should of course be inconsistent with respect to its values.

So our stage is set for the entrance of scientific humanism and we live in the earlier years of what promises to be a new renaissance period. Science is encouraged and supported as never before, and there is enough of prejudiced opposition to arouse us to our best efforts for an ever increasing and broadening appreciation of ourselves and of the world about us. The atmosphere is tense with new knowledge and new inductions, which will soon strike here or there. The world is on its toes to see each new flash. In all their various fields the followers of each science are thoroughly aroused. The progress of discovery and interpretation is greatly accelerated, with an acceleration that is itself continuously accelerated. The present represents a crisis in every branch of science, and we may well examine our several immediate fields of work at this time, to appraise, as best we can, what has been done and to plan for the future with as much broad sanity as we can muster.

In all the fields of science there has developed or is rapidly developing a productive interest in the deeper aspects of the things dealt with. Much has been accomplished in the primary discovery and simple description of forms and colors and other characteristics or properties of objects, much has been done to give us definite knowledge of the arrangement of things in space and of their sequence or succession in time, and now the dynamic aspect of phenomena, with special reference to changes and their causal relations, is becoming increasingly prominent in scientific discussion. The new period into which we are entering, if one may judge so early, appears to be peculiarly characterized by this dynamic point of view. We are in general no longer content with the facts of simple observation, we desire to understand how and why things have come to be as we have found them and how and why they change from period to period and differ from place to place. Perhaps this recent trend of thought toward the more frequent consideration of causal relations in a quantitative way, especially in the

physical and biological sciences, may be regarded as the basis for the rapid rapprochement of science and philosophy that is apparent on every hand.

One of the most remarkable and apparently healthful of recent developments in intellectual affairs is an increasing tendency to disregard or even ignore the older, established but superficial lines of demarcation by which the several fields of knowledge have been so nicely separated. The insulating partitions are disintegrating and thought may now range with relative freedom throughout the entire universe. Workers in one established and named branch make expeditions into other fields and bring back great wealth of new ideas; sometimes they do not return at all but remain at a boundary and enrich two or more branches by their work. Newly developed sciences in many cases occupy border regions and appropriate terrain from several of the older disciplines.

The classification of knowledge is thus being remade. Note how physical science has permeated biological science, how biological studies become starting points for far-reaching progress in the physical sciences, how biology is bringing its parts together into a coördinated whole, how the physiology of plants and lower animals and human beings is being welded into general physiology, how physics and chemistry and astronomy and geology are blending and amalgamating in the hot flux of recent thought at many of their points of contact. Note how philosophy becomes more scientific and science more philosophical, how cosmology and eschatology and even ethics are progressively influenced by natural science, as the findings and methods of the latter slowly permeate into those ancient realms of the free imagination. Note, also, more tangible things: how two or more sections of this American Association combine recently, to hold joint sessions for border-line discussions, how sessions for the discussion of genetics are planned for this aspect of zoology and botany together, how many books appear on physical and mathematical science for biologists—though I have not yet observed so many on biological science expressly prepared for physicists, chemists and mathematicians. Perhaps the next form of classification of the intellectual fields may be largely based on methods of thought and experimentation rather than on superficial charactersitics of the things studied. We

are beginning to try cutting our loaf in new directions and on unwonted lines.

The new era is also notably characterized by interest in science as a whole and in the scientific method in general. The emphasis now being placed on the interrelations between the various branches of knowledge leads to this broader interest and to it is added an importunate demand for the use of the scientific method in all fields of human activity. Industry and art call for scientific research at every turn and the intelligent public desires to know what is going on in research and what may be the general meaning as well as the practical application of each new finding. In every civilized land alert youth, together with many of its elders, is critically examining the organized educational systems of past and present. The resulting conscious desire to improve education is leading to greater emphasis on science in general, less on the particular sciences. The recent rapid growth of the American Association is one sign of the active response of scientific specialists themselves to this broadening influence, for the Association stands preëminently for science as a whole. The rapid development and remarkable success of the National Research Council furnishes another evidence of this remarkable awakening of consciousness among men and women of science in the United States. Not only the public and the press that tries to inform and guide it, but also the research workers themselves, are vitally interested in movements toward the reorganization of the science personnel and the science field. The hope is everywhere expressed that science may eventually organize itself as satisfactorily as it seems already to have organized many fields of art and industry, and that it may consequently furnish humanity with better facilities and greater opportunities for securing the higher pleasures as well as those of more primitive kinds.

GENERAL ORGANIZATION OF PLANT PHYSIOLOGY

Turning now to plant physiology in particular, if it is to maintain its present prominent place among the other sciences and to go forward with them, it must needs become more conscious of its means and aims than it has ever been. Closely related, both by its content and by its philosophical implications, to animal and human physiology and to psychology, as

well as to the physical sciences, plant physiology lies in the region where physical and biological thought meet and blend.

This dynamic branch of the *scientia amabilis* appears to require some reorganization and reclassification of its subject matter, critical examination and improvement of its experimental and logical methods, and improved arrangements to facilitate the dissemination of ideas and the ever more necessary interchange between it and the related sciences. Rapid progress is being made in these things. Especially do the new times call for a larger degree of individual coöperation than has characterized our field in the past and the organization of convenient, comfortable, profitable and efficient means by which many minds and hands may unite in efforts to solve the problems that lie next in our program, so many of which are now in a state that renders individual attack upon them well-nigh hopeless. As was said by the late President Bessey in his address before this Association at Cleveland, in December, 1912, the period characterized by guerrilla methods in the conquest of the unknown is drawing to a close, and suitable organization of research workers becomes increasingly essential.

A widespread desire for improvement in the organization of plant physiologists in this country has just given birth to a new society. Publication facilities for American plant physiology are being increased and promise to be more satisfactory than ever before. The series of monographs called *Physiological Researches*, inaugurated too soon, perhaps, was caught in the trap of financial circumstances and recently came to an end with the close of its second volume; but another journal, *Plant Physiology*, has just been launched under the auspices of the new society. Its pages are to be open to contributions from members and non-members alike and it aims to present only exceptionally high class work. The regularity of its publication (it has begun as a quarterly) will perhaps make this aim somewhat difficult to carry out, but we may be sure that, as far as the available papers will allow, high standards will be maintained. The quality level of its contents clearly will depend on the papers submitted for publication. The recent launching of the *Biological Review* is an important movement for plant physiology as well as for biology as a whole. The inauguration of *Protoplasma* is of specially great importance in the field of

protoplasmic physiology. And physiologists are appreciative of the excellent facilities offered by the recently reorganized *Journal of Agricultural Research* and by *Soil Science*, which likewise has completed a series of volumes and is continuing, as are also the older journals and other serials that present physiological material.

Most important has been the development of *Botanical Abstracts*, the finest project thus far undertaken by American botanists, a project unthought of ten years ago. In some respects it is patterned after *Chemical Abstracts*, which is considerably older. The new renaissance movement in science is well illustrated by the remarkable success of these and other abstract journals. *Botanical Abstracts* is soon to be combined with others in the biological field and enlarged to form *Biological Abstracts*, which is a still greater and broader undertaking, by all sorts of biologists under the auspices of the Union of American Biological Societies. The Union is another very important development of the last few years, illustrating the recent tendency toward active coöperation among the numerous and varied branches of biological science. On the whole, publication of research in plant physiology is being fairly well cared for, the abstracting and indexing of current work is being excellently well done and the future is bright along both these lines.

As to its content and its problems, plant physiology is turning, with the other sciences, to the consideration of questions of dynamics and quantitative causal relations. It is emphasizing the quantitative aspect of its observations and is rapidly moving toward really controlled experimentation for the solution of questions of causality and deterministic control. Hand in hand with physics and chemistry and the rest of physiology, it has so rapidly advanced during the last twenty years that Kostychev can say of its chemical aspect, that only the framework of the subject has survived these two decades of advance and change. This statement is just as applicable to the physical aspect and to the field of irritability and response.

In the following pages of this paper I wish to consider several critical aspects of our science, with reference to its recent past and its probable future. My topics are: Presentation of results of research, The summarizing of research and the providing of text-books, The general exchange of ideas among investigators,

and Research problems, methods and facilities. To the last topic I shall devote most attention.

PRESENTATION OF RESULTS OF RESEARCH

Facilities for the publication of the results of original research in plant physiology are, as I have said, now fairly satisfactory. There is, indeed, no present reason for misgiving in this connection. Research workers are now being asked to write articles for journals and for other channels of publication, and some editors are, I have heard, sometimes a bit put to it to fill their pages. I have myself recently received requests for papers from no less than four scientific journals. It is true that, since most journals require variety in their output and are limited as to size, their editors have to refuse papers that are too long; but short, original articles carry farther and are read more quickly and generally do more for a science, page for page, than do longer ones. Nor is physiology apt to be seriously retarded because of lack of funds for the publication of costly illustrations. Our science has no great need for plates and expensive figures; in general, we do not need to prepare them, we do not need to find funds for their reproduction, and we do not need to handle them in our reading. For this, our field is now much like that of physics and chemistry, but not all scientific branches are so fortunate in this respect. We do, however, need to publish many tabulations and graphs.

It is an interesting observation that recent discussions of the need for improved facilities for research publication have generally contemplated the problem from the standpoint of the author rather than from that of the reader. It has sometimes seemed as if the scientific journals exist and operate primarily to publish John's paper, or to advertise John's institution, with only secondary thought to supplying Richard with helpful and valuable information and new ideas. Doubtless John, as an author—perhaps pressed by his institution—is more importunate and influential than is Richard, as a reader, and you may think of several reasons why this is so. It seems, however, that there is a growing tendency for Richard to clamor a bit now and then for better scientific reading or reading more nearly suited to his wants, and the editors of our publications are not deaf to Richard's wishes, especially since he often appeals to

them in financial terms. I think American scientific editors are coming to exercise their right of choice and criticism more than previously, and I regard this as an excellent and upward-pointing sign.

Not only readers and editors, but also authors, will need to take still more thought in this matter of the quality of research publications, if plant physiology is to proceed as we think it should. We need to realize that, while it does take much time and energy to carry out a piece of research and prepare an article about it, it really consumes, in the aggregate, much more time and energy to read the published account, if a large number of people indulge. The readers should surely be considered, not only those who are with us but also those who are yet unborn. I wish here to refer to the form of presentation only, assuming for the moment that the material to be set forth is unquestionably worthy of presentation.

If you will look critically into any dozen recently published papers in our science, I think you will agree with me that American plant physiology is in grave danger, unless marked improvement can somehow be brought about. We are all too generally hasty and even careless about clearness as well as about succinctness. We often fail to say just what we mean and we not infrequently say things that we do not mean. Our logic is often greatly at fault, our vocabulary and our facility with words are apt to be far too limited. We seem to have come upon a time when a degree of lack in thought precision and in a sense of neatness in literary composition causes less embarrassment than does a corresponding degree of lack in personal dress or table manners. The research worker in science and especially in physiology, now holds the key to the romance of the newer time, and it requires a high degree of art to transfer the products of his thought and scientific imagination from his own mind to the minds of others.

Plant physiology is fundamental to a far-flung galaxy of applied sciences, upon which, as is so often and tritely remarked, largely depend the feeding and clothing and housing of humanity as it increases and fills the world. Consequently, many who are not specialists in our field need to read our research contributions. This is one great practical reason for giving necessary attention to the literary side of our work. We supply

our products to many kinds of minds and if we are fair salesmen we shall try to market these products in convenient and efficient, even attractive, packages. Furthermore, science is international and polyglot; perhaps more of the readers of your research article will know English only as a book language than will have it as their mother tongue. For that large—or at least more widely scattered—group of readers in the present and in the future, clearness and precision of statement are specially requisite. Finally, the recent recruits to any science, from whose number will necessarily come the leaders of the next generation, must begin to read and use our original contributions long before they can have cultivated a knowledge and enthusiasm that will make up for our carelessness or superciliousness or plain laziness in literary composition.

From these different points of view, and from many others also, our greatest present need is not for more or more prompt publication of research in our field, but for better presentation on the part of our authors themselves, who may well bear in mind—what may sometimes be a bit startling—that the main reason for scientific publication is, after all, to inform and stimulate and please the readers. It will not do now for us to hide our literary weaknesses behind the thought that a reader is proved to be stupid if he is unable to get out of our papers what we vaguely intended to put into them. It is clearly the author's business to guard against possible stupidity or ignorance on the part of his readers. Writing can generally be done in periods when we are at our best mentally and when time may be taken to look up questionable points so as to care for many aspects of our presentation. On the other hand, reading is generally done when the reader's mind is more or less passive; a reader likes to be carried along by the author, without much necessity for constructive thinking on his own part and without having to make up for hiatuses or other imperfections in the author's composition.

One of the most frequent inadvertences of recent American writers in our field is failure to provide the reader with adequate orientation and with lucid interpretation. A few sentences of orientation help very greatly to catch the interest and stimulate the imagination, and most readers need that sort of help in most cases. Many who should be greatly interested in our

reports will surely fail to realize that fact unless we provide an intellectual ramp in each case, upon which their minds may easily come to the level of our thought. These are not stupid, they are merely engrossed with their own work on their own levels. Good ramps—sometimes even elevators—are needed.

Similarly, it is not to be expected that many of those who have use for our contribution will take pencil and paper and work over our published results to extract the meaning they bear. Great care is generally required to make sure that our statements may be both clear and as brief as is consistent with clearness and easy reading. Like a beginning student in an elementary laboratory course, the average reader needs to have his attention called to the things he is to see. He may subsequently either agree or dissent, but he has a right to expect us to show him clearly what are our conclusions and how we come to them.

One more point and I shall have done with this sort of preachment. Graphs and diagrams and sometimes pictures are, as every one knows, an enormous help in the transfer of ideas from one mind to another. These are frequently essential in plant-physiological presentations. But they should be illustrations, throwing light on the text; they cannot take its place. Different minds note different things in the same drawing, and actual statements are needed whether illustrations are employed or not. I think most readers of our contributions will be appreciative and thankful if we make definite statements in words of whatever we think should be remembered, even when these points are shown by our illustrations. A science such as ours must have clear expression in sentences; it cannot dare to risk possible miscarriage of ideas such as is apt to occur from the cursory examination of published figures.

THE SUMMARIZING OF RESEARCH AND THE PROVIDING OF TEXT BOOKS

We all agree that the abstracting and indexing of our current plant physiological literature, as of current biological literature in general, is in good hands and is going forward satisfactorily. Conditions in this regard have completely changed since 1918. The machinery of *Botanical Abstracts*, and now of *Biological Abstracts*, seems to be adequate for the near future, and we may feel sure that improvement will be continually made. With

regard to summaries and hand-books of plant physiology, we are not nearly so well cared for, though some excellent monographs on special parts of this field have recently appeared. The literature is now far too extensive and various to be grasped by a single mind, even with the great aid of abstracts. A comprehensive hand-book as satisfactory as Pfeffer's was for its own time is not apt to be produced ever again. Future summaries will almost certainly be monographs on separate phases and by different authors or different groups.

Perhaps the greatest literary need of our science at present is for comprehensive monographs of this sort, such as Stiles's recent one on photosynthesis or Burgerstein's on transpiration. This great need should be consciously cared for in some regular and consistent manner; the preparation of monographs ought not to be left entirely to individual initiative. Perhaps the technical societies might make this a regular part of their service to their members and to the science, arranging for the preparation and publication of monographs and for their revision from time to time. The main difficulty is not the printing and distribution but the securing of suitable manuscripts; that is, finding authors and editors who can and will do the work, which must be largely labor of love.

We now experience great need also for advanced text-books and for elementary treatises. The difficulties before us here are similar to those just mentioned. Perhaps the advanced texts of the future, and possibly even the elementary ones, may be of coöperative authorship. We may derive suggestions from other branches of science, but these general projects will need to receive serious attention from the ablest plant physiologists.

In connection with the suggestion that arrangements for monographs might be taken up by organizations devoted to plant physiology—and arrangements for text-books might also be cared for by such organizations—it may be possible for a scientific society actually to publish such books itself (just as societies publish journals), or for a group of societies to form a publishing association for that purpose. Such a plan, if it might be successfully worked out, should greatly benefit the science. If we consciously and seriously consider all ways and means for advancing our science, some such suggestion will be worthy of thorough study.

THE GENERAL EXCHANGE OF IDEAS AMONG INVESTIGATORS

The complexity of the problems in a field of plant physiology makes it highly desirable that investigators in such a field should have easy and natural means for the exchange of ideas in ways less formal and stereotyped than by the printed page. This thought has been back of the organization of scientific societies, and the annual and other meetings of our societies are of very great value in promoting natural personal intercourse among those who attend. But the programs of these meetings are now generally so filled with papers formally presented that they do not sufficiently encourage and facilitate the sort of intercourse and mutual criticism that all desire. Much constructive thought needs to be given to this phase of our work and it is beginning to receive attention. I meet everywhere with the suggestion that a program committee might place on its program only a relatively few selected papers to be read, leaving much time for discussion, but this suggestion is not often carried out as yet. It will not be sufficient simply to provide time for discussion and criticism. These need to be encouraged by preliminary arrangements that are often more important than the selecting of formal papers. It might be well to give regularly an hour or more to a properly selected paper, rigidly confining the author's reading of the paper itself to a small fraction of that time and having two or more other persons prepared and ready to criticise and discuss the presentation. If discussion were thus started it would generally continue, I think, being taken up by others of those present.

The presentation of five or six ten-minute contributions in an hour at annual meetings of our large societies will need to be discontinued if our meetings are to be as useful as they should be. These meetings should proceed in a leisurely manner with much time purposely left unoccupied by the program itself, time that may be used for personal and informal conferences. Afternoons generally might be left open in that way. The purpose of a meeting might be to promote and facilitate informal discussion and the exchange of ideas, a few properly selected papers being placed on the program to stimulate this exchange. Another promising suggestion is that there might be an exhibition in connection with each meeting and that certain periods be set aside for visiting it and conferring with the exhibitors,

who would be present for that purpose. A striking demonstration is a great catalyzer of discussion and thought.

RESEARCH PROBLEMS, METHODS AND FACILITIES

Interest in plant processes probably first arose from a desire to understand how plants develop, how they grow larger, mature, *et cetera*. These processes or changes are now the subject of our special science. As different sorts of physiological change were discovered and described, the problem of process rates became more prominent and people wished to know when the life changes were slow, and when they were fast, and when they ceased altogether. With some of these questions about time relations and simple sequence more or less satisfactorily answered attention began to turn to the more detailed *manner* in which the rates of plant processes change from time to time, and finally physiology began to come fully to its own with the emergence of problems of causation. At present we are largely occupied in trying to find out the antecedent conditions that determine the processes that go on in the plant. It is specially in connection with these newer problems of causal relations that we now find ourselves in a critical position. For these problems qualitative observations are of but little value, and emphasis is now being strongly placed on quantitative experimentation.

The last decade or so has been specially characterized by this turning from predominantly qualitative to increasingly quantitative work in plant physiology. The standard plants (commonly called controls or checks) of our experiments are given greater prominence and they are selected with ever greater care and receive ever more attention, since they form the bases or datum points from which comparisons are to be made. On the other hand, for the variously treated plants or tissues or organs in an experiment the particular treatments are now generally more definitely known than heretofore. It has been found that we cannot hope to fix upon the exact influences that control a plant process unless we have very precise quantitative knowledge of all the influential conditions, as well as of the process itself, as its rate differs with different treatments. Whether the externally influential conditions of any experiment are artificially made and controlled or are naturally produced, it is now realized as essential that all of them should be quantita-

tively described, precisely enough to render the entire environmental complex reproducible, or at least capable of being identified if it is ever encountered again. Unless the conditions of an experiment are known in such a way, the experiment is of little or no value, and inferences of causal relations cannot be satisfactorily drawn. It is therefore absolutely necessary that we have available apparatus and methods by which data may be secured that will adequately describe both internal and external sets of influential conditions.

Our ideas as to what should constitute good or even passable experimentation with plants have been almost completely changed in the last quarter-century. It used to be taught that a perfect experiment consisted in maintaining all but one influential condition and letting the single remaining condition differ from test to test in known ways and to known degrees. But if we go no further than that our results will mean very little and we shall have nearly wasted our time, as far as really advancing science is concerned. It is essential that the maintained influential conditions be just as precisely known and described as is the variable one. Otherwise we have no logical basis for any definite conclusions and our experiment cannot be repeated, or even recognized if it should ever happen to be repeated. Most physiological experimentation is very poor indeed, excepting as preparation for the use of better methods, unless this very fundamental and very obvious consideration is held in mind.

We have now arrived at a stage in the progress of our science where the things just mentioned are becoming generally appreciated by research workers. But the apparatus and methods by which effective conditions may be controlled and measured are generally not yet available; they remain mostly to be devised. The present crisis finds us fairly well able to recognize the essentials of valid experimentation and reasoning, but we are generally unable as yet to carry out experiments that will fulfill our specifications. From this sort of impasse there is only one rational escape. We cannot now go back and again content ourselves with simple sequential descriptions of what we observe to happen in our plants, nor can we go on indefinitely guessing at causal relations without the quantitative data that are requisite for logical analyses. Opinions as to possible causal

relations are now directly interesting in our science only if they lead to improvements in experimentation and methods of reasoning. The only escape from the impasse lies in devising and employing adequate instruments to give the necessary numerical data and in devising and employing adequate methods for treating such data in ways to bring out any causal relations that may be uncovered by our experimental procedure.

It is almost as though a new world had been opened for exploration. Our whole field lies before us in the new light, all unexamined with respect to quantitative causality or deterministic control. You can scarcely make a single statement about plant processes without raising new and enticing problems that seem to be approachable by experimental methods that we should now be able to work out. Contemplated in this way, these are indeed thrilling times. But our next expeditions into the unknown need to be manned and outfitted with a care and thoroughness that were never required before. We have mental habits that must be watched carefully or we shall be likely to go forward along circular paths. This change in our science must come gradually, for the older fashions of the great pioneers are still prevalent and will remain so; there will perhaps never be a time when qualitative experimentation and opinionated discussion will not occupy prominent places.

During the period when physiology has been turning to quantitative methods and more rigid analysis for discovering causal relations, its content and thought have been adopted almost wholly by pathology and ecology and all that group of applied sciences which comprise the applicational aspect of ecology. Much of pathology and a good part of ecology have become physiological and the same is true of agronomy, horticulture and forestry, which are the ecology of cultivated or practically useful plants. These now deal largely with physiological problems. Physiology as such would probably have come eventually, but perhaps more slowly, to the quantitative study of causal realtions; but its natural tendency in that direction has been greatly hastened by the demands of pathology and the various branches of ecological study. The applied sciences require just as much knowledge of determining conditions as can possibly be secured, for their main aim is to develop the arts of plant production and conservation by informing

growers and handlers of plants how to control plant growth, etc., by the modification of natural conditions or the substitution of artificial ones. Only through knowledge of causal relations can we hope to accomplish these ends. So plant physiology is driven forward, by practical demand as well as by the logic of its own problems, to questions of quantitative dynamics and of the deterministic control of the vital processes.

On the other hand, the superficial and generally hurriedly planned physiological experimentation of ecology and the related applied sciences tend somewhat to retard progress toward more refined types of study, because their problems are so numerous and insistent and because many of them are commercially and politically and economically so important. These branches demand experimental results promptly and in large number and their workers generally have little time or energy or patience for working out the most satisfactory kinds of experimentation and interpretation. With some pronounced exceptions, their experiments are not generally satisfactory to thorough-going physiology, excepting in a suggestive way, but they do serve to maintain interest and they sometimes indicate empirical solutions of practical problems in plant growing. Perhaps they retard physiological progress somewhat by their common tendency to disregard the logic of careful analysis, frequently attempting to substitute short-cuts in place of well planned and thoroughly interpreted experimentation. Some may be led to regard these attempts, which are commonly just empirical tests made for practical purposes, as truly physiological experiments.

But the deeper physiology has gained much from this kind of work, superficial as it confessedly is, and it is well to remember that our science has reached its present state largely through such studies. We should not now be about ready for deeper-going and more thorough investigations if so much relatively superficial and empirical work had not been done. Inadequately planned and carried out, partly observational and partly experimental, with only a few of the essential variables quantitatively measured, and with inadequate experimental control and only superficial interpretive analysis, such pioneer work served our science through its earlier phases of growth and must continue to be very useful, especially in general education and in the applications. But the best physiological work can no longer be after that pattern.

As I have said, experimentation on the relations between the rate of a process and the conditions that determine that rate essentially requires that numerical indices be secured to represent the process rate itself and also the intensities or rates of all the influential conditions; but we can seldom fulfill these requirements to a satisfactory degree. We are generally still unable even to enumerate all the conditions that should be measured or controlled.

Preliminary experiments are generally necessary to find out what are the main influences that need to be considered, and the best present work is largely in such preliminary experimentation. Even for the influential conditions with which we are qualitatively acquainted, we are generally not yet able to secure numerical indices, either for want of proper instruments and methods or for want of knowledge as to how to handle and apply quantitative numerical data after they have been secured. It is thus seen that, although we are bent on the quantitative study of causal relations, we find it thus far impossible to carry out experiments according to our ideals or in ways that even approach our ideals. I judge that hardly a single passingly satisfactory experiment has ever been performed with plants. The group of unknown or unmeasured influences called "chance" have played too great a rôle. As Francis Bacon knew, chance needs to be eliminated from science generally and this is especially true in respect to physiology.

This condition of affairs is characteristic of the present crisis. We begin to know what we wish to do and we enthusiastically attempt to do it by inadequate plans and procedures, although we are aware beforehand that our experiments will generally fail. We secure results that may be quite adequate in some respects but just as hopelessly inadequate in others, thus defeating our own purpose. We publish "little contributions with blunted conclusions," as far as causal relations are concerned. We spend our money in printing elaborate tables of numerical data that represent the precise truth for a certain set of unmeasured conditions, which, however, we do not and cannot define. Our most careful measurements and integrations are too frequently expressed in terms that do not properly apply to the problem in hand and we know not how to weight or interpret them so as to make them satisfactorily applicable.

It is no wonder that many of our experiments cannot be repeated and that our discussions teem with attempts to employ merely qualitative knowledge for the testing of quantitative hypotheses, or hypotheses that should be quantitative if they were really and permanently useful.

Such thoughts as these seem to be a bit discouraging in the first instance, for they indicate that we are undertaking to begin to read the book of physiological causation without adequate knowledge of its language, or even of its alphabet. We understand many letters and a good many words of that book, but most of its sentences and every one of its chapters confront us with relations for which we do not have the proper keys. But we must remember that causal relations in vital phenomena constitute the most difficult and intrinsically complicated subject with which human understanding has to grapple. Our problems are necessarily vastly more complicated than those of the physical sciences, for vitality is not a part of their field. Perhaps the only group of vital phenomena that are still more complicated than those of plants are those of nerve phenomena in the higher animals, including the field of psychology. Still, the living plant presents problems whose solution, it seems, would form a generalized basis for the study of nerve.

Of course it is not to be expected that the problems of plant physiology may lend themselves to relatively easy solution. Their intrinsic complexity is our only possible reason for discouragement and, looked at rightly, this very complexity constitutes the stimulation and challenge of our science. We shall not be discouraged nor pessimistic. *Ignoramus* is an important word in our present vocabulary, and it is a great achievement to recognize when and where we do not know, but the word *ignorabimus* is not ours. In the present crisis we may say, "We do not yet know but we intend to investigate and find out." We surely have no historical basis for thinking that lack of present understanding of complex phenomena is any reason for admitting the possibility that we may not be able to gain understanding by scientific investigation. Science has plenty of time to approach its goal and our only fear may be that we may be less efficient than we might be, thus failing to receive the highest pleasures of the finest intellectual art.

Problems involving the thorough treatment of determining

conditions will generally not be approachable by single investigators working alone, even after the needed methods and instrumentation shall have been worked out. For every physiological process there are a number of influential conditions to be taken into account and these generally fluctuate from period to period; consequently a useful set of quantitative data, for the study of any process in relation to the conditions that may influence it, can be secured only through the making of many simultaneous measurements at intervals throughout a long period. Even when we employ the few recording or integrating instruments that are thus far available for our work, the actual labor of conducting a well planned experiment on the causal relations of processes in living plants is generally much too great for any individual, no matter how active and dexterous and foresighted he may be. Also, many experiments require hourly or more frequent observations of plants and instruments throughout a period of twenty-four hours or more, and an investigator finds it difficult to maintain his best mental condition through such long periods. Finally, the artificial control of conditions like temperature and air humidity require rather elaborate instrumentation and attention from time to time. Whether we arrange an experiment with artificially controlled conditions or set about it to measure natural conditions, or if we attempt both together, we find that the outstanding problems now confronting us are all too complicated to be handled by any individual. Much can and will still be accomplished by individual workers, but it is practically certain that the great future experiments, by which adequate consideration of deterministic control will be brought eventually into our science, will be carried out more and more by groups of coöperating workers.

Here we have another characteristic by which the future of physiology promises to differ from its past. It has been said frequently that coöperation among scientific investigators is highly desirable, but for our fields it is now absolutely essential. The new period will be especially one of group operations. It will be necessary, as is already becoming evident in places where these broader and more exacting problems are taken up consciously and seriously, for a number of workers to pool their intellectual and technical ability and work together on the same general investigation. We can learn much from the

organized methods of industrial research and from the work carried out by some government and institutional laboratories. Ways must be found by which human individualism may be satisfied or sublimated without interfering with the consciously planned progress of great investigations. I have not the temerity to attempt to predict how this will be accomplished, but I do wish to emphasize the thought that such accomplishment is absolutely necessary.

When a group of workers, including several scientific investigators and their assistants, purchasing agents, mechanicians, mechanics, computers, clerks, typists, laborers and janitors, shall combine their efforts to begin really planned experimentation on the control of plant processes, it will of course be necessary that they have special laboratory facilities, such as are thought of in connection with the best physical, chemical, meteorological and medical research institutes, but they will require much more. Excellent beginnings along some of the lines here suggested have been made in this country at the Boyce Thompson Institute for Plant Research and in some of the offices of the United States Department of Agriculture. It does not seem likely that suitable laboratories for such broad and complicated experimentation will be generally possible directly in universities, though the new type of research institute may well be connected in some highly satisfactory way with a new type of university that will probably soon begin to make its arrival evident. A point to be emphasized is that fundamental research will be the main aim of such establishments, the training of advanced students being no primary part of their activities. Nor will the insistent practical problems of agriculture or forestry be allowed to usurp the attention of the workers. There will always be, as there now are, many laboratories where attention will be primarily devoted to practical problems, but institutes for particular fields of plant physiology will need to devote themselves only to the fundamentals; they will need to have no direct connection either with experiment stations or with education as such. Of course they will derive ideas and probably workers from the fields of applied science and their assistants will naturally and automatically receive the best possible advanced training. These assistants will be employed to do needed work, much as in an industrial laboratory, and they

will learn and grow, but they should not generally receive fellowships nor should they work for degrees in the present mode. The details of housing and personnel organization will of course need to be worked out.

The realization of such a dream as this will necessitate large funds, for current expenses as well as for original equipment. Much of apparatus and supplies will need to be purchased and much will need to be devised and specially made. The purchase of ready-made instruments and other apparatus is of course a form of coöperation, the makers of the apparatus thus aiding the investigators in specific ways and receiving payment in return.

We may well cultivate familiarity with the general idea of group research in our science. The idea is already being put into practice little by little, in this branch as well as in others. It will surely come to be a dominant idea and a commonly accepted mode. We may well try to prepare the way for the undertaking, by groups, of such broad and complex and consciously planned research as I have suggested. What are the essential preliminaries in the accomplishment of which we, as individual men of science, may now engage?

As we have said, funds will be necessary. We may further this general idea, in our writing, teaching and conversation and in our interviews with news writers. Let it be understood that plant physiology is as worthy of and as ready for adequate research facilities and endowment as is astronomy, chemistry, general botany, medical science or any other field of scientific investigation. This field excels in opportunity for the advancement of pure science, by which I mean the philosophical appreciation of the universe; for plant physiology occupies the borderline between the physical sciences and the sciences that deal with human thought and feeling. The basic problems of protoplasmic properties and reactions may, in general, be best attacked in this field. We are probably not in danger of anti-vivisection laws, and experimentation with plants is probably not intrinsically repulsive to any one. This field also excels in possibilities for the advancement of the arts, for the application of scientific knowledge in agriculture, horticulture, forestry and the industries and vocations that deal with plant products. The relation of plant physiology to plant production and the handling of plant

products is similar to the relation of animal physiology to hygiene, medicine, and animal husbandry. The arts that rest on plant physiology are the most fundamental and necessary to civilization. Its applications in daily life are the practical business of the majority of human beings for most of their waking hours. Chemistry and physics have given to industry many processes by which plant products are modified, but these operations still depend upon plant growth for most of their materials. Whenever it shall come to pass that a good part of the organic materials for human food and protection may be synthetically prepared without resort to living plants, you may be sure that the keys to the new industries will come largely from plant physiology. Perhaps, as is often said, the most important process in nature, from the standpoint of humanity, is the photosynthesis of carbohydrate from water and carbon dioxide, and this process of green plants presents one of the basic problems of plant physiology as well as of chemistry. We are not apt to secure our carbohydrates without the use of plants until we shall have understood much better than we do now the physiological process or processes of photosynthesis. Indeed, the suggestion is patent that special institutes for the investigation of this particular field of plant physiology should be the first or among the first to be established.

It is remarkable that plant physiology has accomplished so much in its period of pioneering and individualistic researches, but the new times demand new and larger methods here as elsewhere, and laboratories for this science ought not much longer to be the poorly-equipped affairs with which we are all too familiar. If these thoughts and other similar ones may become familiar to the intelligent public there is no reason why we may not see the establishment of such institutes as we have in mind.

University laboratories have now the burden of finding and training minds that will be capable of handling the great problems that lie so clearly before us. Promising students may be encouraged, not only to become experts in certain fields of our subject but to grasp the major projects of the planning and interpretation of comprehensive research by coöperating groups. Men and women who are now students or beginners will be the ones upon whose shoulders will fall the new mantle of this great responsibility. There is plenty of bright outlook for

students of our subject who can master its many-sidedness and devote themselves to its service. This thought applies also to students in laboratories other than those of plant physiology, for the coöperating groups of which we dream will require minds trained in physics and chemistry, in plant morphology and climatology, in soil science, animal physiology and even astronomy. Indeed, the new plant physiology promises to offer excellent opportunities to the largest number of competent and versatile minds trained primarily in these related subjects. At any rate, the most complex of chemical and physical problems are to be found in the physiological field and the most generally interesting features of non-living masses and particles are, after all, their influences on the vital processes. Having gone so far in understanding the general causal relations of material and energy changes in non-living systems, human intelligence may now make rapid progress toward solving at least some portions of the riddle of life. But the best minds will be needed, and also much of the wealth of knowledge and thought, principle and idea, that have already been accumulated in the realm of the sciences of the non-living.

Perhaps the most pressing need of our science now, as it begins to approach more consciously the causal aspects of plant phenomena, is the need for new or improved instruments and methods, which shall be suited to the routine operations of well-planned physiological experimentation. Consider how inadequate our experimental methods generally are and consider that most outstanding contributions to physiological knowledge involve new technique or improved apparatus and could not be accomplished without it. In experimental procedure the impossible must continually be made possible. We require better means for controlling experimental conditions, better means for measuring the intensities and fluctuations of the processes we are studying and of the influential conditions that affect those processes. Every dynamic characteristic of the organism and every effective dynamic characteristic of the environmental complex needs rational and creative study, by the aid of which may be invented or devised new instruments or methods that will give us the measurements we require, and in suitable terms. How to secure useful measurements of variable conditions and how to integrate our numerical values

into calculated indices that may be compared with other indices secured by direct measurements of the results or products of the processes dealt with—these are our most insistent questions.

These preliminary problems of apparatus and methods are fortunately approachable without very special equipment and without very special arrangements for coöperation, though of course alert mentality and technical skill are demanded. They are questions with which most of us are busied now, and there is much more to be done before we shall be ready for the greater undertakings that lie in the offing. There is no limit to this field of endeavor and no question of the constructive value of and necessity for the results to be secured. We cannot hope that our present experimentation or that of the near future will throw much more than suggestive light on the causal relations that we are hoping to discover eventually, but we can make ready for better planned and interpreted experimentation by groups, when that shall become more feasible. Individual workers can now work out separate tools and methods that will be brought together in the more complex operations of the future. And the new times will bring no end to this kind of individualistic work, for tools and methods will always need to be improved.

In this connection it may be pointed out that, for the present and immediate future, contributions in instrumentation and technique should be regarded as much more important than any general conclusions that may be derived from most of our commonly only abortive attempts to obtain reliable knowledge of causal relations by short-cuts that are not planned to succeed in the broader way. It is not our surmises and opinions or statistical calculations of probable concomitancy or correlation that are of lasting importance. Temporarily interesting and stimulating as these indeed are, they pertain more to the category of amusement and imaginative recreation than to that of really constructive progress. We need to hold in high esteem the devising and adequate testing of new methods and the logical improvement of older methods, for upon such work the future of our science depends.

DESERT LABORATORY, TUCSON,
SEPTEMBER, 1926.

INDEX TO AMERICAN BOTANICAL LITERATURE
1923–1926

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Adams, J. A survey of Canadian plants in relation to their environment. Bull. Dept. Agr. Canada 58: 1-60. 1926.

Adams, J. F. Plant diseases and their control in relation to climatic conditions in Delaware. Trans. Peninsula Hort. Soc. 15[3]: 39-43. 1926.

Alcock, N. L. A preliminary note on a *Phytophthora* on *Atropa belladonna*. Pharm. Jour. **116**: 232. *illust.* 27 F 1926.
P. erythroseptica var. *Atropae*.

Amann, J. *Mnium arizonicum* sp. nova. Rev. Bryologique **52**: 23-25. 1925.

Ames, R. S. Another station for *Lycopodium* prothallia. Am. Fern Jour. **16**: 26. 11 Mr 1926.
Near Wheaton College, Norton, Mass.

Anderson, E. G. A dominant brown pericarp color in maize. Papers Michigan Acad. Sci. **5**: 73-75. "1925" 1926.

Angell, H. R. Oospore-like bodies in cultures of *Phytophthora infestans*. Ann. Rep. Quebec Soc. Prot. Plants **17**: 79-81. *illust.* 1925.

Annand, P. N. *Thysanoptera* and the pollination of flowers. Am. Nat. **60**: 177-182. Mr-Ap 1926.

Arthur, J. C., & **Kern, F. D.** The problem of terminology in the rusts. Mycologia **18**: 90-93. 1 Mr 1926.

Ashby, S. F., & **Nowell, W.** The fungi of stigmatomycosis. Ann. Bot. **40**: 69-83. *pl. 4, 5.* Ja 1926.
Genus *Spermophthora* from the West Indies, and several species in *Nematospora*, described as new.

Babcock, E. B., & Lesley, M. M. Chromosome number and individuality in the genus *Crepis*. II. The chromosomes and taxonomic relationships. Univ. California Publ. Agr. Sci. **2**: 315–341. *f. 1–7*. 6 Mr 1926.

Bailey, J. W. *Philonotis calcarea* Schimp. in western Washington. Bryologist **29**: 5–6. "Ja" 13 Mr 1926.

Barrus, M. F., & Chupp, C. Potato diseases and their control. Cornell Ext. Bull. 135: 1–123. *f. 1–35*. Mr 1926.

Bartram, E. B. *Mnium arizonicum* Amann. Bryologist **29**: 30–31. *f. 1*. "Mr" 1926.

Bartram, E. B. A variety of *Didymodon mexicanus* Besch., in Arizona. Bryologist **29**: 1–2. *pl. 1*. "Ja" 13 Mr 1926.
Variety *subulatus*.

Bartram, E. B. *Weisia sinaloensis* not a *Weisia*. Bryologist **29**: 8. "Ja" 13 Mr 1926.
Hyophila sinaloensis.

Bassler, H. *Musa* in tropical America. Jour. N. Y. Bot. Gard. **27**: 49–54. *col. pl. 301, 302*. Mr 1926.

Belling, J. On photographing chromosomes. Jour. Roy. Micr. Soc. **1925**: 445–446. *illust*. D 1925.

Belling, J. A unique result in certain species crosses. Zeitsch. Induk. Abstamm. Vererbungslehre **39**: 286–288. 1925.

Berry, E. W. *Terminalia* in the lower Eocene of southwestern North America. Bull. Torrey Club **53**: 59–65. *f. 1–6*. 27 F 1926.
T. vera described as new species.

Blizzard, A. W. The nuclear phenomena and life history of *Urocystis Cepulae*. Bull. Torrey Club **53**: 77–117. *f. 1* + *pl. 1–4*. 27 F 1926.

Boros, A. A new parasitic fungus on mosses. Bryologist **29**: 2. "Ja" 13 Mr [illegible]5.
Cladosporium herbarum.

Bower, F. O. Plants and man: a series of essays relating to the botany of ordinary life. i-ix, 1–365. *f. 1–148*. New York & London, MacMillan Co., 1925.

Boyd, O. C. Root knot in Georgia tobacco in 1925, and how to prevent it. Georgia S. Bd. Entomology Circ. 39: 1–9. N 1925.

Brentzel, W. E. The pasmo disease of flax. Jour. Agr. Res. **32**: 25–38. *f. 1 + pl. 1–5.* 1 Ja 1926.

Brieger, F. G. Mendelian factors producing selective fertilization. Am. Nat. **60**: 183–191. Mr-Ap 1926.

Briggs, L. J., Campbell, A. B., Heald, R. H., & Flint, L. H. Electroculture. U. S. Dept. Agr. Bull. 1379: 1–34. *f. 1.* Ja 1926.

Brockmann-Jerosch, H., & Brockmann-Jerosch, M. Jamaica. Vegetationsbilder 16^{5-6}: *pl. 25–36.* 1925.

Brooks, C., & Fisher, D. F. Some high-temperature effects in apples; contrasts in the two sides of an apple. Jour. Agr. Res. **32**: 1–16. *f. 1, 2 + pl. 1–4.* 1 Ja 1926.

Brooks, C., & Fisher, D. F. Water-core of apples. Jour. Agr. Res. **32**: 223–260. *f. 1–9 + pl. 1.* 1 F 1926.

Buchholz, J. T. Origin of cleavage polyembryony in conifers. Bot. Gaz. **81**: 55–71. *f. 1, 2 + pl. 5–7.* 22 Mr 1926.

Burret, M. *Neotessmannia*, eine neue Tiliaceen-Gattung. Notizbl. Bot. Gart. Berlin **9**: 125–127. 1 O 1924.
N. uniflora from Peru.

Carsner, E. Seasonal and regional variations in curly-top of sugar beets. Science II. **63**: 213–214. 19 F 1926.

Chambers, R. The action of electrolytes on the physical state of protoplasm. Am. Nat. **60**: 121–123. Mr-Ap 1926.

Clark, J. A., Martin, J. H., & Stakman, E. C. Relative susceptibility of spring wheat varieties to stem rust. U. S. Dept. Agr. Circ. 365: 1–18. *f. 1, 2.* F 1926.

Clinton, G. P. Fungous and non-infectious troubles of ornamental trees. Connecticut Agr. Exp. Sta. Bull. 263: 171–192. *pl. 9–16.* D 1924.

Clum, H. H. The effect of transpiration and environmental factors on leaf temperatures. I. Transpiration. Am. Jour.

Bot. **13**: 194–216. *f. 1–5.* 11 Mr 1926. II. Light intensity and the relation of transpiration to the thermal death point. Am. Jour. Bot. **13**: 217–230. *f. 1–5.* 26 Ap 1926.

Cockerell, T. D. A. Ellsworth Bethel. Science II. **63**: 201–202. 19 F 1926.
Born 20 June 1863. Died 8 S 1925.

Cockerell, T. D. A. The supposed fossil *Ophioglossum*. Torreya **26**: 10–11. 27 F 1926.

Colby, A. S., & Anderson, H. W. Diseases of brambles in Illinois and their control. Illinois Agr. Exp. Sta. Circ. 305: 1–20. *f. 1–3 + col. pl.* F 1926.

Conn. H. J. Soil flora studies. III. Spore-forming bacteria in soil. IV. Non-spore-forming bacteria in soil. New York (Geneva) Agr. Exp. Sta. Tech. Bull. 58: 1–16. *f. 1–4.* Mr 1917; 59: 1–18. Mr 1917.

Conn, H. J. Soil flora studies. VI. The punctiform-colony-forming bacteria in soil. New York (Geneva) Agr. Exp. Sta. Tech. Bull. 115: 1–26. O 1925.

Cook, O. F. Cotton classed in the field. Production standardized by maintaining uniform varieties. Jour. Hered. **17**: 3–9. *f. 1, 2.* 18 F 1926.

Corne, F. E. Ferns—facts and fancies about them–VIII. Am. Fern Jour. **16**: 20–24. 11 Mr 1926.

Couch, J. F. Relative toxicity of the lupine alkaloids. Jour. Agr. Res. **32**: 51–67. 1 Ja 1926.

Curtis, O. F. What is the significance of transpiration. Science II. **63**: 267–271. 12 Mr 1926.

Dahlgren, B. E. The cannon-ball tree; the monkey pots. Field Mus. Nat. Hist. Dept. Bot. Leaflet 6: 1–8. *pl. 1–6.* 1924.
Couroupita guianensis.

Davidson, J. Changes in nitrogen, potassium, and phosphorus content of wheat seedlings during germination and early stages. Bot. Gaz. **81**: 87–94. 22 Mr 1926.

Davis, W. H. Life history of *Ustilago striaeformis* (Westd.) Niessl. which causes a leaf smut in timothy. Jour. Agr. Res. **32**: 69–76. 1 Ja 1926.

Dayton, W. A. Notes on the type locality of *Pentstemon micranthus* Nuttall. Proc. Biol. Soc. Wash. **39**: 11–13. 23 F 1926.

DeBruyn, H. L. G. The overwintering of *Phytophthora infestans* (Mont.) De By. Phytopathology **16**: 121–140. *f. 1–3.* F 1926.

Demerec, M. Notes on linkage in maize. Am. Nat. **60**: 172–176. Mr-Ap 1926.

Dozier, H. L. Insect pests and diseases of the satsuma orange. Educational Bull. Gulf Coast Citrus Exch. 1: 1–101. *illust.* Au 1924.

Dickson, B. T. Mosaic of rhubarb. Ann. Rep. Quebec Soc. Prot. Plants **17**: 25–27. *illust.* "1925" 1926.

Dickson, B. T. Oat smut control in 1924. Ann. Rep. Quebec Soc. Prot. Plants **17**: 35–36. "1925" 1926.

Dodge, B. O. Organization of the telial sours in the pine rust, *Gallowaya pinicola* Arth. Jour. Agr. Res. **31**: 641–652. *f. 1 + pl. 1, 2.* "1" D 1925.

Duggar, B. M., & Armstrong, J. K. The effect of treating the virus of tobacco mosaic with the juices of various plants. Ann. Missouri Bot. Gard. **12**: 359–366. "N 1925" 1926.

Erlanson, E. W. The wild roses of the Mackinac region of Michigan. Papers Michigan Acad. Sci. **5**: 77–94. "1925" 1926.

Everard, L. C. Arbor day; its purpose and observance. U. S. Dept. Agr. Bull. 1492: 1–18. *f. 1–5.* Mr 1926.

Farwell, O. A. *Botrychium dissectum.* Am. Fern Jour. **16**: 25–26. 11 Mr 1926.

Fawcett, G. L. Las enfermedades de la cana de azucar en Tucuman. Bol. Est. Exp. Agr. Tucuman 1: 1–47. *f. 1–26.* S 1924.

Fawcett, G. L. El herrumbre o "russet" de los naranjos. Rev. Ind.y Agr. Tucuman **15:** 157–159. Ap-My 1925.

Fick, G. L., & Hibbard, R. P. A method for determining seed viability by electrical conductivity measurements. Papers Michigan Acad. Sci. **5:** 95–103. "1925" 1926.

Gaerlan, S. A. Comparative amounts of gases carbon dioxide, oxygen and nitrogen found in the body of certain plants. Philipp. Agr. **14:** 557–567. F 1926.

Gaines, E. F., & Singleton, H. P. Genetics of Marquis × Turkey wheat in respect to bunt resistance, winter habit, and awnlessness. Jour. Agr. Res. **32:** 165–181. *f. 1–3.* "15 Ja" F 1926.

Garrett, A. O. *Asplenium viride* and *Cryptogramma Stelleri* in Utah. Am. Fern Jour. **16:** 27–28. 11 Mr 1926.

Gates, F. C. Evaporation in the *Scirpus validus* and *S. americanus* associations. Bot. Gaz. **81:** 95–102. *f. 1 + pl.8.* 22 Mr 1926.

Gates, F. C. Evaporation in vegetation at different heights. Am. Jour. Bot. **13:** 167–177. 11 Mr 1926.

Gilbert, B. E. Interrelation of relative day length and temperature. Bot. Gaz. **81:** 1–24. *f. 1–5.* 22 Mr 1926.

Gillis, M. C. A genetical study of the fertility of the lateral florets of the barley spike. Jour. Agr. Res. **32:** 367–390. *f. 1–4.* 15 F 1926.

Girola, C. D. Plantas medicinales. Min. Agr. Nac. Sect. Prop. Inf. Circ. 231: 1–84. *illust.* 1924.

Graves, A. H. An unusual insect gall on scarlet oak (*Quercus coccinea* Muench.) Torreya **26:** 1–2. *illust.* 27 F 1926.

Grout, A. J. Studies in *Fabronia.* Bryologist **29:** 4–5. "Ja" 13 Mr 1926.
Species *F. Bartramii* and 2 varieties, described as new.

Grout, A. J. Two interesting mosses from New Mexico. Bryologist **29:** 8–9. "Ja" 13 Mr 1926.
Brachythecium Wootonii described as new species.

Harlan, H. V., & Pope, M. N. Development in immature barley kernels removed from the plant. Jour. Agr. Res. **32**: 669–678. *f. 1 + pl. 1.* 1 Ap 1926.

Harms, H. Über die Gattung *Megalopanax* Ekman. Notizbl. Bot. Gart. Berlin **9**: 121–124. 1 O 1924.
M rex from Havana.

Harris, J. A. The relationship between the concentration of the soil solution and the physicochemical properties of the leaf-tissue fluids of Egyptian and upland cotton. Jour. Agr. Res. **32**: 605–647. *f. 1–6.* 1 Ap 1926.

Harris, J. A., Hoffman, C. T., & Hoffman, W. F. Sulphate content of the leaf-tissue fluids of Egyptian and Upland cotton. Jour. Agr. Res. **31**: 653–662. "1 O" D 1925.

Harrison, G. J., & King, C. J. Age of seedlings as a factor in the resistance of maize to sodium chloride. Jour. Agr. Res. **31**: 633–640. "1 O" D 1925.

Harrison, J. B. Food plants of British Guiana. Jour. Bd. Agr. British Guaina n. s. **19**: 18–51. Ja 1926.

Harrison, K. A. Physiological specialization of *Colletotrichum Lindemuthianum* in eastern Canada. Ann. Rep. Quebec Soc. Prot. Plants **17**: 45–62. *pl. 5, 6.* 1925.

Harrison, K. A. Preliminary report on a disease of common bean. Ann. Rep. Quebec Soc. Prot. Plants **17**: 62–69. *pl. 7.* 1925.
Phyllosticta phaseolina.

Harshberger, J. W. Rhythmic or seasonal appearance of orchids. Bartonia 8: 7. D 1924.

Hedrick, U. P., Howe, G. H., Taylor, O. M., Berger, A., Slate, G. L., & Einset, O. The small fruits of New York. Ann. Rep. N. Y. S. Dept. Farms & Markets **33**[2]: i–xi, 1–614. [94] *col. pl.* Albany, 1925.

Hill, H. Wintering over and infection of *Puccinia Malvacearum* Mont. Ann. Rep. Quebec Soc. Prot. Plants **17**: 81–84. 1925.

Hoffman, I. C. The relation of size of kernels in sweet corn to evenness of maturity. Jour. Agr. Res. **31**: 1043–1053. *f.* 1 + *pl. 1* "1 D 1925" Ja 1926.

Hubbard, C. E. Vasey grass in Africa. Kew Bull. Misc. Inf. **1926**: 94–96. F 1926.
Paspalum Larranagai.

Imai, Y. Inheritance of pubescence in *Pharbitis nil.* Bot. Gaz. **81**: 103–107. 22 Mr 1926.

Jehle, R. A. Apple scab and its control. Trans. Peninsula Hort. Soc. **37**: 9–12. 1924.

Johnson, G. Edible greens. Bartonia 8: 8. D 1924.

Johnson, J. Mosaic disease on differential hosts. Phytopathology **16**: 141–149. *pl. 10–14.* F 1926.

Kanouse, B. B. On the distribution of the water molds, with notes on the occurrence in Michigan of members of the Leptomitaceae, and Blastocladiaceae. Papers Michigan Acad. Sci. **5**: 105–114. *pl. 1.* "1925" 1926.

Kauffman, C. H. The fungus flora of Mt. Hood, with some new species. Papers Michigan Acad. Sci. **5**: 115–148. *pl. 2–13.* "1925" 1926.

Keeley, F. J. *Pleurosigma Boyeri:* a new diatom from Florida. Proc. Acad. Nat. Sci. Phila. **77**: 31–32. *illust.* 4 Je 1925.

Keitt, G. W. Some relations of environment to the epidemiology and control of apple scab. Proc. Natl. Acad. Sci. **12**: 68–74. *f. l.* 15 F 1926.

Kempton, J. H. Correlated characters in a maize hybrid. Jour. Agr. Res. **32**: 39–50. *f. 1–3.* 1 Ja 1926.

Kesselring, W. *Veratrum californicum* Durand. Gartenflora **75**: 58–60. *illust.* F 1926.

Kiesselbach, T. A. Winter wheat investigations. Nebraska Agr. Exp. Sta. Res. Bull. 31: 1–149. *f. 1–30.* N 1925.

King, C. J., & Loomis, H. F. Experiments on the control of cotton root rot in Arizona. Jour. Agr. Res. **32**: 297–310. *pl. 1, 2.* 15 F 1926.

Kobbe, F. W. The smooth *Woodsia* in New York. Am. Fern Jour. **16**: 29–31. 11 Mr 1926.

Kraus, E. J. Factors regulating growth and fruitfulness and causes of non-production in fruit trees. Hoosier Hort. **7**: 183–191. D 1925; **8**: 10–15. Ja 1926.

Krueger, A. P., & Alsberg, C. L. A metabolic study of *Bacterium solanacearum* E. F. S. Proc. Soc. Exp. Biol. & Med. **21**: 534. My 1924.

Kylin, H. The marine red algae in the vicinity of the biological station at Friday Harbor, Washington. K. Fysiografiska Sällsk. Handl. n. f. **36**[9]: 1–87. *f. 1–47*. 1925.

Lewis, C. S. Ferns of the Marcy region. Am. Fern Jour. **16**: 10–17. 11 Mr 1926.

Lockhead, A. G. The bacterial types occurring in frozen soil. Soil Sci. **21**: 225–231. Mr 1926.

Long, B. Some changes in the aspect of the list of the Philadelphia flora. Bartonia 8: 12–32. D 1924.

Longley, A. E. Chromosomes and their significance in strawberry classification. Jour. Agr. Res. **32**: 559–568. *f. 1, 2*. 15 Mr 1926.

McAtee, W. L. Some local names of plants—IV. Torreya **26**: 3–10. 27 F 1926.

McAvoy, B. One way to grow ferns. Am. Fern Jour. **16**: 28–29. 11 Mr 1926.

McIntosh, T. P. Origin, early history, and development of the potato. Gard. Chron. III. **79**: 49, 85, 120, 159–160, 178. 16, 30 Ja; 13, 27 F; 6 Mr 1926.

McKay, M. B. Further studies of potato wilt caused by *Verticillium albo-atrum*. Jour. Agr. Res. **32**: 437–470. *f. 1–5 + pl. 1–7*. 1 Mr 1926.

McWhorter, F. P. A simple method for making differential counts of small spores. Science II. **63**: 211–212. 19 F 1926.

Mains, E. B. Rye resistant to leaf rust, stem rust, and powdery mildew. Jour. Agr. Res. **32**: 201–221. *pl. 1–6.* 1 F 1926.

Mains, E. B., & **Jackson, H. S.** Physiologic specialization in the leaf rust of wheat, *Puccinia triticina* Erikss. Phytopathology **16**: 89–120. *pl. 6–9.* F 1926.

Marsh, C. D., Clauson, A. B., & **Roe, G. C.** Nuttall's death camas (*Zygadenus Nuttallii*) as a poisonous plant. U. S. Dept. Agr. Bull. 1376: 1–13. *f. 1–3.* F 1926.

Maxon, W. R. New tropical American ferns—III. Am. Fern Jour. **16**: 7–9. 11 Mr 1926.
Notholaena Ekmani described as new species.

Merrill, E. D. New species of plants from Indo-China. II. Univ. California Publ. Bot. **13**: 127–143. 6 Mr 1926.

Mitchell, E. Germination of seeds of plants native to Dutchess County, New York. Bot. Gaz. **81**: 108–112. 22 Mr 1926.

Moxley, E. A. The bryophyte beautiful. Bryologist **29**: 6–7. "Ja" 13 Mr 1926.

Moxley, G. L. The quest of *Thelypteris augescens.* Am. Fern Jour. **16**: 17–20. *pl. 2.* 11 Mr 1926.

Nelson, A. The members of the genus *Agrostis* important in the seed trade, with special reference to the nomenclature. Ann. Appl. Biol. **13**: 55–63. F 1926.

Newton, D. E. The bisexuality of individual strains of *Coprinus Rostrupianus.* Ann. Bot. **40**: 105–128. *f. 1–17* + *pl. 6.* Ja 1926.

Orton, C. R. Seeds as carriers of disease. Jour. N. Y. Bot. Gard. **27**: 54–63. Mr 1926.
Abstract of a lecture.

Orton, W. A. Botanical problems of American tropical agriculture. Bull. Torrey Club **53**: 67–75. 27 F 1926.

Parodi, L. R. Notas sobre flores cleistogamas axilares en las aveneas platenses. Rev. Facult. Agron. Buenos Aires **4**: 508–514. D 1924.

Peltier, G. L. A study of the environmental conditions influencing the development of stem rust in the absence of an alternate host. III, IV, V, VI. Nebraska Agr. Exp. Sta. Res. Bull. 34: 1–12. O 1925. 35: 1–12. N 1925.

Peltier, G. L., & Frederich, W. J. Effects of weather on the world distribution and prevalence of citrus canker and citrus scab. Jour. Agr. Res. **32**: 147–164. *f. 1–9.* "15 Ja" F 1926.

Peltier, G. L., & Frederich, W. J. Further studies on the overwintering of *Pseudomonas citri*. Jour. Agr. Res. **32**: 335–345. *pl. 1–3.* 15 F 1926.

Pennell, F. W. The genus *Afzelia*: a taxonomic study in evolution. Proc. Acad. Nat. Sci. Phila. **77**: 335–373. *f. 1–10.* Mr 1926.

Many species described as new.

Pennell, F. W. The genus *Allophyton* of southern Mexico and Guatemala. Proc. Acad. Nat. Sci. Phila. **77**: 269–272. 9 D 1925.

A. evolutum and *A. mexicanum*, described as new combinations.

Pennell, F. W. The pollination of two tidewater Scrophulariaceae. Bartonia 8: 9–11. D 1924.

Hemianthus micranthus and *Ilysanthes dubia inundata*.

Pieters, A. J. Charles Vancouver Piper. Science II. **63**: 248–249. 5 Mr 1926.

Born 16 Je 1867. Died 11 F 1926.

Ramsey, G. B. *Sclerotinia* species causing decay of vegetables under transit and market conditions. Jour. Agr. Res. **31**: 597–632. *f. 1–3* + *pl. 1–7.* "1 O" D 1925.

Ranker, E. R. Determination of total nitrogen in plants and plant solutions; a comparison of methods with modifications. Ann. Missouri Bot. Gard. **12**: 367–380. *pl. 19.* "N 1925" 1926.

Reed, G. B. A striking example of negative heliotropism. Canad. Field Nat. **40**: 23–25. *illust.* F 1926.

Rehder, A. New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum. Jour. Arnold Arbor. **7**: 22–37; 145–149. "Ja" 4 Mr; "Ap" 1926.

In *Taxodium*, *Pinus*, *Clematis*, *Ribes*, *Exochorda*, *Malus*, *Pyrus*, *Ribes*, *Pyconia*, *Rubus*, *Glochidion*, *Euonymus*, *Vitis*, *Tilia*, *Rhododendron*, *Syringa*, *Campsis*, and *Lonicera*.

Reimers, H. Beiträge zur Bryophytenflora Südamerikas. I, II. Hedwigia **66**: 27–78. *f. 1–6.* Ja 1926.

Rex, E. G. Experiments on the control of black-leg disease of cabbage. Pennsylvania Agr. Exp. Sta. Bull. 199: 1–23. *f. 1–10.* O 1925.

Riker, A. J. Studies on the influence of some environmental factors on the development of crown gall. Jour. Agr. Res. **32**: 83–96. *f. 1–2* + *pl. 1–3.* 1 Ja 1926.

Roach, W. A. & **Brierley, W. B.** The treatment of wart disease of potatoes with sulphur. Science II. **63**: 307–308. 19 Mr 1926.

Robinson, C. H. Photographing wild flowers. Flow. Grow. **13**: 124, 128. *illust.* Mr 1926.

Robinson, M. F. Tree buds—their story. Nat. Mag. **7**: 219–222. *illust.* Ap 1926.

[**Rock, J. F.**] The Arnold Arboretum expedition to north central Asia. Jour. Arbor. **7**: 68–70. "Ja" 4 Mr 1926.

Two letters from Mr. Rock dated October 8 and 25, 1925.

Rost, C. E. *Maierocactus* gen. nov. Zeit. Sukkulent. **2**: 138–142. D 1925.

Sargeant, C. S. Corrections and emendations of the second edition of Sargent's Manual of the Trees of North America. Jour. Arnold Arbor. **7**: 1–21. "Ja" 4 Mr 1926.

Sartoris, G. B., & **Kauffman, C. H.** The development and taxonomic position of *Apiosporina Collinsii*. Papers Michigan Acad. Sci. **5**: 149–162. *f. 5* + *pl. 14–17.* "1925" 1926.

Satina, S., & **Blakeslee, A. F.** Biochemical differences between sexes in green plants. Proc. Natl. Acad. Sci. **12**: 197–202. 15 Mr 1926.

Satina, S., & Blakeslee, A. F. The *Mucor* parasite *Parasitella* in relation to sex. Proc. Natl. Acad. Sci. **12**: 202–207. 15 Mr 1926.

Satina, S., & Blakeslee, A. F. Studies on biochemical differences between (+) and (—) sexes in Mucors. 2. A preliminary report on the Manoilov reaction and other tests. Proc. Natl. Acad. Sci. **12**: 191–196. 15 Mr 1926.

Schneiderhan, F. J. Apple disease studies in northern Virginia. Virginia Agr. Exp. Sta. Bull. 245: 1–35. *illust.* F 1926.

Schreiner, R., & Snow, L. M. An unusual strain of *Serratia marcescens bizio*. Science II. **63**: 18–19. 1 Ja 1926.

Seaver, F. J. Mycophagy. Mycologia **18**: 94–95. 1 Mr 1925.

Seifriz, W. Elasticity as an indicator of protoplasmic structure. Am. Nat. **60**: 124–132. Mr-Ap 1926.

Setchell, W. A., & Watson, M. G. Social ecological relations of the hypogaeous fungi. Science II. **63**: 313–315. 19 Mr 1926.

Shamel, A. D. The improvement of sugar cane through bud selection. Rep. Exp. Sta. Hawaiian Sugar Pl. Assoc. **1924**: 1–120. *illust.* 1925.

Sherff, E. E. Studies in the genus Bidens. VII. Bot. Gaz. **81**: 25–54. *pl. 1–4.* 22 Mr 1926.
Several species and varieties described as new.

Skinner, J. J., & Demaree, J. B. Relation of soil conditions and orchard management to the rosette of pecan trees. U. S. Dept. Agr. Bull. 1378: 1–16. *pl. 1–8.* F 1926.

Smith, E. F. Black chaff of wheat in Russia. Science II. **63**: 305–307. *f. 1.* 19 Mr 1926.

Smith, H. H. European botanical gardens. Wisconsin Hort. **15**: 172–174. *illust.* Jl 1925; **16**: 22–23. O 1925: 34–35. N 1925; 50–51. D 1925; 66–67. Ja 1926; 82–73, 87. F 1926.

Spegazzini, C. Fungi paraguayenses. An. Mus. Nac. Hist. Nat. Buenos Aires **31**: 255–340. pl. 23. 1923.
2 genera, *Xanthospora* and *Amylis*, and many species, described as new.

Spegazzini, C. Relacion de un paseo hasta el Cabo de Hoorn. Bol. Acad. Nac. Cien. Argentina **27**: 321–404. *illust.* 1924.

Sprague, T. A. Standard species. Kew Bull. Misc. Inf. **1926**: 96–100. F 1926.

Standley, P. C. Carlos Werckle. Science II. **63**: 221–223. 26 F 1926.
Born 1860. Died 24 N 1924.

Stanford, E. E. *Polygonum hydropiperoides* and *P. opelousanum* Rhodora **28**: 11–17; 22–29. "Ja" 17 F; "F" 1 Ap 1926.
Several varieties described as new.

Stevenson, J. A. Foreign plant diseases. A manual of economic plant diseases which are new to or not widely distributed in the United States. U. S. Dept. Agr. Off. Secretary. i–viii, 1–198. Washington, 1926.

Stone, W. Stewardson Brown. Bartonia. 8: 1–6. *illust.* D 1924.
Born 27 Ap 1867. Died 14 Mr 1921.

Taylor, W. R. Chromosome morphology in *Fritillaria*, *Alstroemeria*, *Silphium*, and other genera. Am. Jour. Bot. **13**: 170–193. *f. 1–60.* 11 Mr 1926.

Thompson, W. P. *Marsilea vestita* Hook. and Grev. in western Canada. Am. Fern Jour. **16**: 24–25. 11 Mr 1926.

Tims, E. C. On the nature of resistance to cabbage yellows. Jour. Agr. Res. **32**: 183–199. *f. 1. 2.* "15 Ja" F 1926.

Tisdale, L. E. Colloidal sulphur; preparation and toxicity. Ann. Missouri Bot. Gard. **12**: 381–418. *pl. 20.* "N 1925".

Tisdale, W. H., & **Johnston, C. O.** A study of smut resistance in corn seedlings grown in the greenhouse. Jour. Agr. Res. **32**: 649–668. *pl. 1–3.* 1 Ap 1926.

Transeau, E. N. The accumulation of energy by plants. Ohio Jour. Sci. **26**: 1–10. Ja 1926.

Tucker, C. M. A leaf, bract, and boll spot of sea-island cotton caused by *Helminthosporium Gossypii* n. sp. Jour. Agr. Res. **32**: 391–395. 15 F 1926.

Tucker, C. M. *Phytophthora* bud rot of coconut palms in Porto Rico. Jour. Agr. Res. **32**: 471–498. *f. 1–20.* 1 Mr 1926.

Ulbrich, E. *Septotheca* Ulbrich eine neue Gattung der Bombacaceae. Notizbl. Bot. Gart. Berlin **9**: 128–135. *f. 3.* 1 O 1924.

Uphof, J. C. T. Dendrologische notizen aus dem staat Florida. II. Mittelöstliches und nordliches Florida. Mitt. Deut. Dendrol. Gesell. **35**: 219–225. *f. 1* + *pl. 31, 32.* 1925.

Upholf, J. C. T. Die teparybohne (*Phaseolus acutifolius*). Tropenfl. **29**: 43–46. F 1926.

Wakabayashi, S. The injurious effect of submergence on the cranberry plant. New Jersey Agr. Exp. Sta. Bull. 420: 1–26. *f. 1–4.* D 1925.

Walcott, M. V. North American wild flowers. v. 1. *col. pl. 1–80,* with test. Washington, D. C., Smithsonian Inst., 1925.

Walker, J. C., & **Wellman, F. L.** Relation of temperature to spore germination and growth of *Urocystis Cepulae.* Jour. Agr. Res. **32**: 133–146. *f. 1–3* + *pl. 1.* "15 Ja" F 1926.

Walton R. C., & **Orton, C. R.** The perfect stage of *Cylindrosporium pomi* Science II. **63**: 236. 26 F 1926.

Waters, C. W. The reactions of bean rust grown on leaves in solutions. Papers Michigan Acad. Sci. **5**: 163–177. *f. 6–8.* "1925" 1926.

Weatherby, C. A. *Lygodium palmatum* in Berkshire county, Massachusetts. Am. Fern Jour. **16**: 26–27. 11 Mr 1926.

Wehmeyer, L. E. Cultural life-histories of certain species of *Eutypella, Diatrypella* and *Cryptovalsa.* Papers Michigan Acad. Sci. **5**: 179–194. *pl. 18.* "1925" 1926.

Weimer, J. L. Ringspot of crucifers caused by *Mycosphaerella brassicicola* (Fr.) Lindau. Jour. Agr. Res. **32**: 97–132. *f. 1, 2* + *pl. 1–6.* "15 Ja" F 1926.

Weimer, J. L., & Harter, L. L. Root rot of the bean in California caused by *Fusarium Martii Phaseoli* Burk. and *F. aduncisporum* n. sp. Jour. Agr. Res. **32:** 311–319. *pl. 1–3.* 1 F 1926.

Welch, D. S. A monographic study of the genus *Cucurbitaria* in North America. Mycologia **18:** 51–86. *f. 1–5* + *pl. 7, 8.* 1 Mr 1926.

Wherry, E. T. Notes on some local plants and their soil acidity. Bartonia 8: 33–34. D 1924.

Wherry, E. T. Soil reaction preferences of three Adder's-tongues. Am. Fern Jour. **16:** 1–3. 11 Mr 1926.

Wherry, E. T. Wood ferns on Mt. Desert Island, Maine. Am. Fern Jour. **16:** 3–7. *pl. 1.* 11 Mr 1926.

Wielamd, G. R. The El Consuelo Cycadeoids. Bot. Gaz. **81:** 72–86. *f. 1.* 22 Mr 1926.

Wiggans, C. B. The influence of certain environmental and cultural conditions on fruit-bud formation of pear and apricot. Jour. Agr. Res. **31:** 865–883. *f. 1, 2* + *pl. 1–6.* "1 N 1925" Ja 1926.

Wilson, B. D., & Wilson, J. K. An explanation for the relative effects of timothy and clover residues in the soil on nitrate depression. Cornell Agr. Exp. Sta. Memoir 95: 1–21. N 1925.

Wilson, E. B. Newer aspects of the alveolar structure of protoplasm. Am. Nat. **60:** 105–120. *f. 1–5.* Mr-Ap 1926.

Wilson, E. H. The Taxads and conifers of Yunnan. Jour. Arnold Arbor. **7:** 37–68. "Ja" 4 Mr 1926.

Wilson, P. Trees and shrubs in winter. Jour. N. Y. Bot. Gard. **27:** 63–67. Mr 1926.

Withycombe, C. L. Studies on the aetiology of sugar-cane froghopper blight in Trinidad. I. Introduction and general survey. Ann. Appl. Biol. **13:** 64–108. *f. 1–4.* F 1926.

Woodcock, E. F. Morphology of the seed in *Claytonia virginica.* Papers Michigan Acad. Sci. **5:** 195–200. *pl. 19, 20.* "1925" 1926.

Woolett, E., Dean, D., & **Coburn, H.** An ecological study of Smith's Bog, Cheboygan County, Michigan. Papers Michigan Acad. Sci. **5:** 201-210. *map* + *pl. 21.* "1925" 1926.

Wright, P. A., & **Shaw, R. H.** A laboratory study to determine the best time to ensile corn, sunflowers and sudan grass. Jour. Agr. Res. **32:** 321–333. 15 F 1926.

Young, R. T. The life of Devils Lake, North Dakota. Publ. No. Dakota Biol. Stat. 1–114. *f. 1–45* + *pl. 1–22.* 1924.
Annotated list of species—Bacteria pp. 57–93.

Zundel, G. L. Notes on the Ustilagineae of Washington. Mycologia **18:** 87–89. 1 Mr 1926.

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